TECHNICAL AND SCALE EFFICIENCY IN ZAMBIA'S AGRO-PROCESSING INDUSTRY: A FIRM LEVEL DATA ENVELOPMENT ANALYSIS OF THE 2011/2012 MANUFACTURING CENSUS

DAVID KAPYA
(KPYDAV001)

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School of Economics
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ABSTRACT

The implementation of privatization and Structural Adjustment Programs in Zambia saw the contribution of manufacturing in GDP significantly reduce from 37.2 percent in 1992 to 8.2 percent in 2013. Efforts to revamp manufacturing have not delivered to expectations and the industrial base has continued to be smaller than it used to be in the 1970s and 1980s. This has raised serious questions about suitable industrialization policies not only for Zambia but for other African countries as well.

This study examines the agro-processing industry with a view to establish whether it can drive the development of Zambia's manufacturing. We start by exploring the growth opportunities and highlighting the key sectors of comparative advantage. Thereafter, we apply the Data Envelopment Analysis algorithm to construct measures of technical and scale efficiency for a sample of 115 firms using the 2011/2012 Economic Census data. Finally, we examine the effect of firm attributes on the firm's technical and scale efficiency using the Tobit regression model.

The results reveal that there are sufficient growth opportunities in Zambia's agro-processing industry, but the industry is highly inefficient. The average technical efficiency was 42.5 percent while scale efficiency was 81.7 percent. The study also shows that firm efficiency is affected by firm size, the size of the firm's market share, labour costs, and location of the firm.

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CHAPTER 1: INTRODUCTION

Zambia's economic transition from a centralized to a liberalized economic system in the early 1990s resulted in significant structural changes in the manufacturing sector which the country has not recovered from yet. The manufacturing sector only accounts for eleven percent of GDP and has continued to decline with the share of employment still under four percent of all employed persons (Zambia Development Agency: 2014). Zambia inherited a strong specialized economy anchored on the mining industry when it became independent in 1964. The rapid growth in GDP, of 8.7 percent between 1966 and 1976, was not only stimulated by high copper prices, high government expenditures on infrastructure and services as well as investments in the manufacturing enterprises but was further boosted by the Unilateral Declaration of Independence (UDI) in Zimbabwe (formerly known as Southern Rhodesia) on the 11th November, 1965. The declaration was met with the first economic sanctions to be imposed by the United Nations which prompted manufacturing companies in Zimbabwe to set up manufacturing plants locally in Zambia to protect their markets (Fundanga & Mwaba: 1997).

Like any newly-independent country, Zambia embarked on economic reforms aimed at addressing the economic inequalities the country was facing, which culminated in the adoption of the "Mulungushi Reforms" (named after the location, Mulungushi Rock of Authority, at which the policy pronouncements were made by the then president Kenneth Kaunda) in 1968. These policies resulted in nationalization, and saw the state acquiring a fifty-one percent ownership in twenty-five large companies mostly in manufacturing, transport, distribution and construction (Kaunga: 1995). The "Matero Reforms" (named after a Lusaka suburb where the policies were pronounced) quickly followed in 1969 and led to the acquisition of fifty-one percent equity holding by the state in mines owned and run by Anglo-American corporation and Roan Selection Trust which were the biggest mining companies at the time (Kaunga: 1995; Fundanga & Mwaba: 1997). The nationalization of mines virtually wiped out private sector participation in the economy. The government controlled eighty percent of the economy in sectors such as mining, agriculture, milling, brewing, hotels and tourism, housing and construction, transportation (including airlines and passenger bus services), bakeries, timber and wood products, electricity to water reticulation and sanitation. With parastatal entities accounting for fifty-three percent of the manufacturing share in GDP and forty-two percent share in total employment by the end of 1972 (Kaunga: 1995), the government had become the engine of growth. In this period, the share of manufacturing (% of GDP) grew steadily from 6.92 percent in 1965 to 37.16 percent in 1992 as a result of these economic and import substitution policies which characterized economic management as shown in Figure 1.

Zambia's economic buoyancy has always been closely tied to international copper price. Therefore, following the oil crisis of the mid-1970s, the mining's share of GDP fell sharply from 33 percent in 1976 to just 11.5 percent in 1977, a dramatic drop of more than 65.1 percent (UNIDO, 2013; CSO, 2014[a]). The downward trend continued until the early 2000s when copper prices started to recover.

Fiscal implication was far reaching and resulted in unsustainable government borrowing. Total external debt grew by 242.2 percent between 1976 and 1987 as government sort to cover the loss in foreign earnings from copper exports and continue subsidizing the state owned enterprises while GDP per capita declined reaching its lowest value of US$556.5 in 1994 (World Bank[b]; 2015). Efforts by the state to keep the economy afloat saw the creation of several state run manufacturing companies that spread employment equitably across all provinces with each province specializing in a specific kind of manufacturing. These specialists' industries included cashew nuts in the Western province, pineapple production and processing in North-Western province, motor vehicle and radio assembly plants in Southern province, textile industry in Central province, bicycle industry in Eastern province and a battery plant in Luapula province (UNIDO: 2013). By the early 1980s, high energy import costs and lower copper earnings combined with poor monetary policy resulted in hyperinflation and high interest rates. By the end of 1990, annual inflation rate had risen to near 120 percent and food shortages became commonplace which resulted in food riots (CSO: 2014[a]).

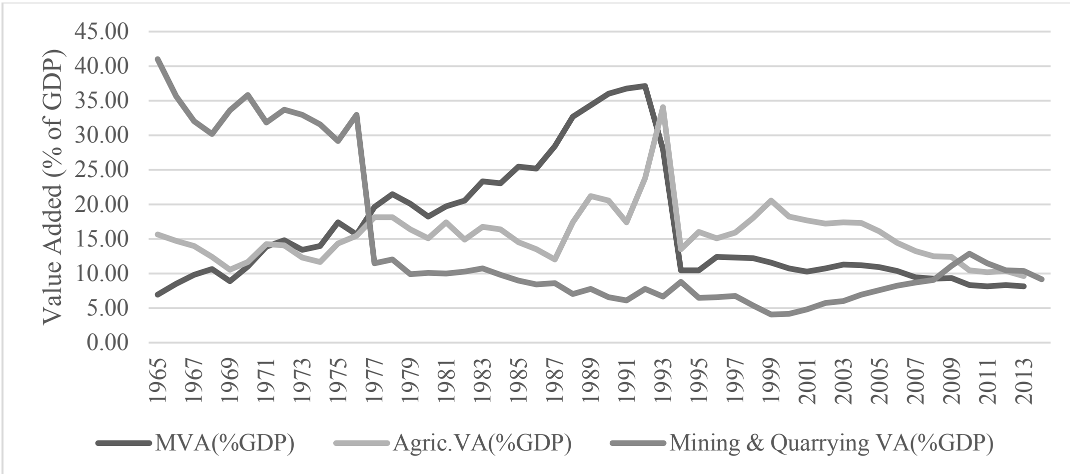

Figure 1: Size and Composition of the Zambian Economy (1965 – 2014)
Source: World Development Indicators

The election defeat of the United National Independence Party (UNIP) in 1991 by the Movement for Multi-Party Democracy (MMD) marked the transition from a state run economy to free market and gave way for the adoption of market orientated policies such as privatization. Privatization and the Structural Adjustment Programs (SAPs) supported by the International Monetary Fund and World Bank became the bedrock policies of the MMD's economic recovery and transformation agenda which was highly accelerated such that by the end of June 1996, the government had wholly privatized a total of 137 companies (Saasa, 1996; Fundanga & Mwaba, 1997). However, the liberalization of the economy also meant the removal of trade tariffs which exposed the local industry to greater competition. The dismantling of tariffs together with wide spread corruption and capital flight which characterized the privatization process significantly resulted in the shrinkage of the manufacturing base as more and more firms exited the industry (UNIDO: 2013). The disappearance of the relatively strong industrial base built by the previous UNIP government caused manufacturing's share of GDP to fall sharply from 37.2 percent in 1992 to 10.4 percent in 1994 (UNIDO: 2013). Recent statistics show that the contribution of manufacturing to total employment fell from 4 percent in 2005 to 3.9 percent in 2012. Though in absolute terms, employment had risen from 166,143 jobs to 216,660. These data indicate that manufacturing did not keep up with GDP growth after liberalization, which raises a serious question about suitable industrialization policies for Zambia in particular and African countries in general.

The industrialization of Africa has been on the development agenda for decades now and has not delivered on the expectations. Economic development is often defined as a structural movement of labour from low productivity jobs in agriculture and mining to higher productivity jobs in manufacturing and tradable services (Mcmillan & Headey, 2014; Page, 2012). This has not been the African experience where a large share of the labour force is still predominant in agriculture and the migrating farm workers are not ending up working in manufacturing but in non-tradable services industry which is both not dynamic and operates below the world technology frontier (Rodrik, 2013; Page, 2012). As a result, the share of manufacturing in GDP has continued to shrink and has remained smaller than it was in the 1970s and early 1980s (Page: 2012). This is in sharp contrast to the experience of East Asian countries that managed to transform farm labour into manufacturing workers which resulted in the diversification of their economies by increasingly exporting sophisticated products in a short period (Rodrik: 2013). Therefore, the challenge for African economies like Zambia is to find manufacturing niches that would become alternative sources of economic development and bring about structural transformation.

Given agriculture's relatively strong performance since the mid-1990s, agro-processing could lead Zambia's reindustrialization process. This dissertation aims to investigate the performance of the agro-processing industry in Zambia with a view to establishing whether it can drive Zambia's manufacturing sector development and bring about structural transformation necessary for sustainable economic development. The approach is total factor productivity analysis and the dataset is the economic census conducted in 2011 and 2012. The argument is that efficiency increases in agro-processing industry will not only result in lower food prices, increased employment and reduced poverty among the poor but is also a plausible pathway to diversification and industrialization of the economy as a whole. In addition to setting industry benchmarks, this study will attempt to identify the key determinants of success with a series of Analysis of Variance tests and Tobit regression models. Specific policy recommendations on how to revitalize manufacturing will be made based on the results.

As background, an exploratory analysis will focus on the performance of the agro-processing industry between 2000 and 2014 with a view to establishing the existing opportunities for growth in the industry. We shall use a series of data from sources such as the World Bank, United Nations' commodity trade and from the World Integrated Trade Solutions (WITS). Thereafter, an analysis of the industry’s technical and scale efficiency will be presented to ascertain the viability of prioritizing the agro-processing industry to drive the development of the manufacturing industry in Zambia.

CHAPTER 2: METHODS

The study of total factor productivity at the firm level originated with Charnes *et al* (1978). It is now regularly applied to all sectors of the economy including in developing countries. For example, Ali (2007), Bhandari and Ray (2007), Ali *et al* (2009), and Tripathy *et al* (2009) analyzed the efficiency of various sectors of the Indian economy including agro-processing, textiles and pharmaceuticals sectors. In Pakistan, the emphasis has been on small, medium and large scale firms (Burki and Terrell, 1998; Burki and Khan, 2004; Raheman *et al.,* 2009). Agro-processing has been studied in Turkey (Taymaz & Saatçi, 1997; Akgöbek & Yakut, 2014), Chile (Lakner *et al*: 2013) and in Bangladesh (Krishna & Sahota: 1991). However, few studies in Africa have concentrated on manufacturing and agro-processing sectors (Siggel, 1992; Lundvall & Battesse, 2000; Gebreeyesus, 2008; and Ngui-Muchai & Muniu, 2012), and in Zambia, the focus has been on the efficiency of public institutions. For example, Masiye (2007) and Masiye *et al*: (2014) studied various aspects of health care, while Chaampita (2010) studied the efficiency in secondary schools. A comprehensive literature review shows that this study is the first to investigate the efficiency of the agro-processing industry for Zambia using a non-parametric approach on a panel data of firms.

Unlike parametric methods, Data Envelopment Analysis algorithm constructs a linear piecewise production frontier from the observed input and output values without any *a priori* functional relationship between them and then calculates the efficiency of a firm within a group relative to observed best practice within that group (Farrell: 1957). The ratio of the physical output to a volume measure of all inputs used for a given technology is defined as total factor productivity (TFP) which is also the standard definition of technical efficiency (OECD, 2001; Review of the Commonwealth Service Provision, 1997). In contrast to partial factor productivity which expresses output per unit of a single input, total factor productivity includes all inputs and outputs. Efficiency and productivity is affected by technology, prices and other aspects of the external operating environment as well as technical and allocative efficiency within the firm; better performance is associated with higher productivity scores, while weaker performances result in lower efficiency ratios (Coelli *et al*: 2005).

The basic Data Envelopment Analysis method is an input oriented CCR method developed by Charnes, Cooper and Rhodes (1978) which is based on the assumption of Constant Returns to

Scale (CRS). Given N number of firms, each with D inputs and M outputs, let the i^{th} firm be represented by the column vector $\mathbf{x_i}$ and $\mathbf{q_i}$ respectively. Following Coelli's *et al* (2005) exposition, the objective of the CCR (CRS) model is to

$$\begin{aligned} &\text{Max } (\mathbf{u}'\mathbf{q_i}/\mathbf{v}'\mathbf{x_i}) \\ \text{Subject to} \quad &\mathbf{u}'\mathbf{q_j}/\mathbf{v}'\mathbf{x_j} \leq \mathbf{1} \qquad (1) \\ &\mathbf{u}, \mathbf{v} \geq \mathbf{0}; \mathrm{j} = 1, 2, 3, \ldots \ldots \ldots, \mathrm{N} \end{aligned}$$

where $\mathbf{x_i}$ = vector of inputs for the i^{th}; **X** = D x N input matrix for N firms; **V** = D x 1 vector of input weights; $\mathbf{q_i}$ = vector of outputs for the i^{th}firm; **Q** = M x N output matrix for N firms; **U** = M x 1 vector of output weights

The CCR model states that the optimal combination of inputs and outputs is independent of the firm's scale of operation, implying that a proportional increase in the inputs, results in a proportional increase in output. However, the objective of the function specified in (1) entails finding values for **u** and **v** such that the efficiency for the i^{th} firm is maximized subject to the constraint that all efficiency measures must be less than or equal to 1.

The non-linear formulation suffers from the problem of infinite number of solutions and is therefore transformed to allow for the maximization of the numerator while restricting the denominator of the objective function. This is achieved by imposing a constraint $\mathbf{v}'\mathbf{x_i} = \mathbf{1}$ to obtain;

$$\begin{aligned} &max_{\mu v}(\mu'\mathbf{q_i}) \\ \text{Subject to} \quad &\nu'\mathbf{x_i} = 1 \\ &\mu'\mathbf{q_j} - \nu\mathbf{x_j} \leq 0 \qquad (2) \\ &\mu, \nu \geq 0; j = 1, 2, 3, \ldots \ldots \ldots \ldots, \mathrm{N} \end{aligned}$$

and the notation changes from **u** and **v** to μ and ν to stress the transformation from a non-linear model to a linear model. The model is then solved using the duality procedure of linear programming to derive an equivalent envelopment form stated as;

$$\begin{aligned} &minimize_{\theta,\lambda}\theta \\ \text{Subject to} \quad &-\mathbf{q_i} + \mathbf{Q}\lambda \geq 0 \\ &\theta\mathbf{x_i} - \mathbf{X}\lambda \geq 0 \qquad (3) \\ &\lambda \geq 0 \end{aligned}$$

where θ is a scalar and is also the efficiency score for the i^{th} firm. It satisfies the condition; $\theta \leq 1$, with a value of 1 representing a point on the frontier and a technically efficient firm. λ is an Nx1 vector.

The CCR model is premised on assumptions that do not hold in cases where the firms' operations are influenced by various factors making them not to operate at optimal levels. Applying CCR model on such cases would yield technical efficiency scores which are not independent of scale efficiencies. Thus, the CCR model was modified into BCC model by Banker, Charnes and Cooper (1984) to allow for calculations of technical efficiency scores devoid of scale effects. This was achieved by adding a convexity constraint; $\mathbf{N1}'\lambda = 1$ to obtain

$$\begin{aligned} & minimize_{\theta,\lambda}\theta \\ \text{Subject to} \quad & -\mathbf{q_i} + \mathbf{Q}\lambda \geq 0 \\ & \theta\mathbf{x_i} - \mathbf{X}\lambda \geq 0 \\ & \mathbf{N1}'\lambda = 1 \\ & \lambda \geq 0 \end{aligned} \tag{4}$$

where **N1** is an N x 1 vector of ones.

The Data Envelopment Analysis algorithm can either be input-oriented or output-oriented. Input-oriented Data Envelopment Analysis defines the frontier by looking for the maximum possible reduction in input use holding output constant while output-oriented Data Envelopment Analysis seeks the maximum proportional increase in output production holding inputs constant (Bonfiglio: 2006). This research adopted the BCC output-oriented Data Envelopment Analysis in (4) because its assumption is more applicable to the industry in that firms seek to maximize output for a given input resources, instead of minimizing inputs to obtain the same level of output.

Efficiency scores obtained can be decomposed into overall technical efficiency, pure technical efficiency and scale efficiency. Overall technical efficiency is a technical efficiency measure obtained under the constant returns to scale (CRS) assumption using the CCR model stated in equation (3) and is useful in explaining the level of firm efficiency relating to input utilization and scale of operation (Farrell, 1957; Kumar & Gulati, 2008; Paradi & Tam, 2012). The components of overall technical efficiency are two mutually exclusive and non-additive measures of pure technical efficiency and scale efficiency. Pure technical efficiency is determined under the assumption of variable returns to scale using the BCC model stated in equation (4) which is purely responsible for the measurement of input utilization in the production process while scale efficiency is the ratio of overall technical efficiency to pure technical efficiency and measures the optimum scale of operation for a given firm (Farrell, 1957; Kumar & Gulati, 2008). A firm is said to be scale efficient when it is operating at the optimal size such that any changes to its size of operation would reduce its efficiency.

Under constant returns to scale, a firm is assumed to be automatically scale efficient unlike variable returns to scale technology, where a firm can either be too small or too large (Coelli *et al*: 2005). If it is too small, a firm is said to be operating under increasing returns to scale and if it is too large, it operates under decreasing returns to scale. In both of these cases, efficiency is improved by adjusting the scale of operation. Therefore, a scale efficiency measure is used to indicate the amount with which productivity can be improved by moving to the frontier. Figure 2 illustrates the relationships between overall technical efficiency, pure technical efficiency and scale efficiency.

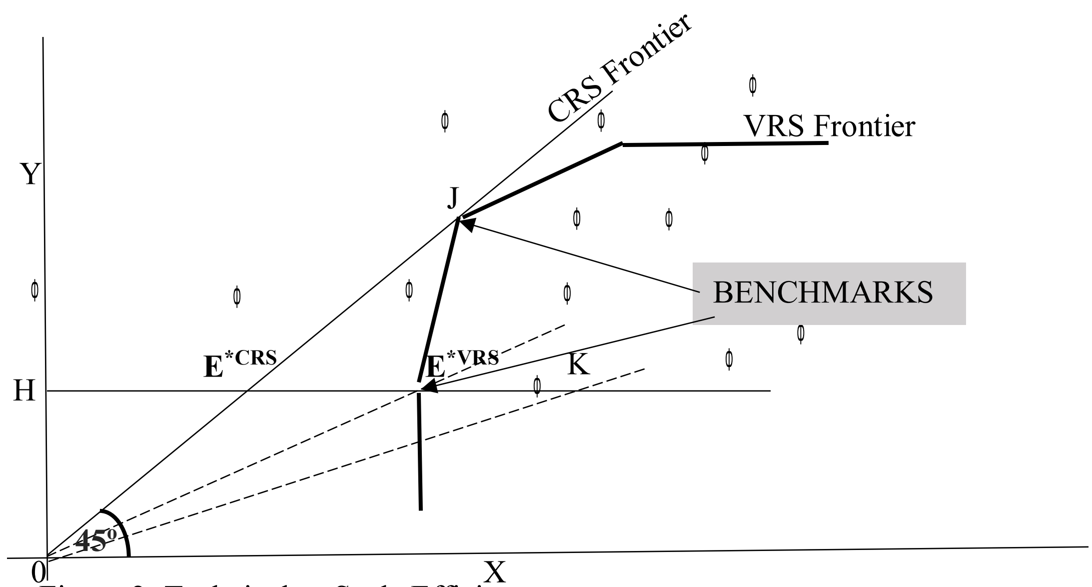

Figure 2: Technical vs Scale Efficiency
Source: Adapted from Burki & Terrell (1998) and Coelli *et al* (2005)

Given a technically inefficient firm K, its productivity can be improved by moving to the technically efficient point E^{*VRS} on the VRS frontier and can further be improved by moving from point E^{*VRS} to point J which is both technical and scale efficient. The movement from point K to point E^{*VRS} ensures that technical inefficiency is removed while a further movement to point J gets rid of scale inefficiency. Assuming that the ratio of the slope 0K to the slope $0E^{*VRS}$ is equal to the ratio HE^{*VRS}/HK and that the ratio of the slope $0E^{*VRS}$ to the slope $0E^{*CRS}$ is equal to the ratio $HE^{*CRS}/_{HE^{*VRS}}$, then technical efficiency of firm K is the distance from point K to the VRS frontier and is given by;

$$Technical\ Efficiency(TE)_{VRS} = HE^{*VRS}/\mathrm{HK}$$

while the Scale Efficiency of firm K is the distance from the technically efficient point E^{*VRS} to the CRS technology frontier given by

$$Scale\ Efficiency = HE^{*CRS}/_{HE^{*VRS}}$$

The scale efficiency measure can also be indirectly estimated by noting that if the distance from point K to the CRS technology frontier can be calculated, then

$$Technical\ Efficiency\ (TE)_{CRS} = HE^{*CRS}/\mathrm{HK}$$

which is then used to calculate Scale Efficiency score as

$$Scale\ Efficiency = \frac{TE_{CRS}}{TE_{VRS}}$$

2.1.1. Industry Benchmarks

In the process of fitting a frontier, the most efficient operations are identified. These might serve as industry benchmarks. For each inefficient firm, the Data Envelopment Analysis algorithm identifies an efficient peer with which an inefficient firm shares one or more factor ratios (Kumar & Gulati, 2008; Sreedevi, 2013). This is depicted in Figure 2 by firm J and firm E^{*VRS} on the frontier which are the role models of good production practices for the inefficient firms and are thus considered as benchmarks. The peer count indicates the number of inefficient firms (frequency) an efficient firm is a benchmark to, while the efficient firms are considered as benchmarks unto themselves. Firms with higher peer counts serve as better benchmarks for the sector with respect to best practices. Therefore, in benchmarking Zambia's agro-processing industry, firms with the highest peer counts (typically above 20) will be regarded as the benchmarks for best practices in the industry and will be given an in-depth analysis to explain the sources of their efficiency.

2.2. Alternative Approaches and Justification for Adopting the DEA Method

There is a parametric alternative to the Data Envelopment Analysis, namely Stochastic Frontier

Analysis (SFA), which is often preferred precisely because it is parametric. However, Stochastic Frontier Analysis is often criticized for its strong assumptions on the distribution of the statistical noise which can easily be confused to mean inefficiency especially when the error term fails to obey the normal distribution assumption (Kumbhakar & Lovell: 2000). Data Envelopment Analysis is still popular for several reasons chief amongst which is that it does not require an *a priori* assumption on functional form, can handle multiple outputs, gives peer information, does not rely on price data and tolerates small sample sizes as well (Shamsudin *et al.*, 2013; Kumar & Gulati, 2008; Banker, 1984).

The Data Envelopment Analysis algorithm is often criticized for assuming that the data used is free of measurement errors which could result in unreliable results if the integrity of the data cannot be assured (Avkiran: 1999). As a remedy, it has been proposed that outliers be discarded.

Finally, one should be careful about comparing efficiencies across studies. Since efficiency levels are calculated with reference to the best performance within a particular group, efficiency scores are inherently not comparable between studies. Even for a given group of firms, different frontier specifications will lead to different mean efficiency scores with more complicated models producing the highest efficiency levels. As the ratio of observations to inputs plus outputs decline, efficiency levels increase to the point where the algorithm produces very little discrimination between firms anymore.

2.3.Fitting the Efficiency Frontier

All the studies reviewed fit a frontier in which some measure of output, usually value added, is related to a small set of inputs, usually capital, labour and intermediate consumption (Rezitis & Kalantzi, 2015; Lakner *et al.*, 2013; Shamsudin *et al.,* 2013; Aedo *et al.*, 2011; Ali, 2007; Bonfiglio, 2006; Burki & Terrell, 1998). In this instance, production process was specified as a combination of three inputs into one output. In the particular definitions used, the literature served as a guide on how to navigate the particular limitations of the Zambian dataset. The variables are summarized in Table 1 and discussed in depth in the sections below.

Productivity analysis based on the concept of gross output disaggregates intermediate input variable into energy, materials and services which are considered important sources of productivity growth. Therefore, according to the OECD (2011), the standard measurement of productivity defines the production function as a function of Capital(K), Labour(L), Energy (E), Materials (M) and Services (S). We restrict the definition of the production function to capital, labour, energy and materials and do away with services (S) because the core business of manufacturing firms is not in offering services but producing tangible products from given input resources (OECD, 2001; Baptist and Hepburn: 2013).

2.3.1. Gross Output

The common measures of output from the literature are Value Added and Gross Output (Rezitis & Kalantzi, 2015; Shamsudin *et al.,* 2013; Ali, 2007; Burki & Terrell, 1998). This thesis opted to use Gross Output because of the nature of the industry where some firms in certain sectors like milling generate their income from receipts for the grain ground on behalf of a client and not from sales. The output variable was therefore measured as a sum of total sales of finished goods produced by the individual firm and receipts received for processing work done on behalf of another firm.

2.3.2. Labour Input

We used the number of total workers employed by the firm as the proxy for Labour input. This included both male and female as well as foreign and local workers. Different studies have used different approaches to measuring labour input. Taymaz & Saatçi (1997) used total number of hours worked in production as a proxy for labour input while many others have used the number of people employed (Lakner *et al.,* 2013; Shamsudin *et al.*, 2013 and Jajri & Ismail, 2006). Ali (2007) measured the labour input as payments made to employees while Bonfiglio (2006) relied on labour costs as the proxy. Therefore, the use of total number of employees for this study is consistent with standard measurement of labour input.

2.3.3. Materials Input

Materials input was estimated as the sum of the cost of raw materials and changes in the stock of raw materials. Materials are part of the intermediate inputs defined as endogenous factors of production which are transformed and used up in the production process within a given accounting year (OECD: 2001). There has been an increasing realization of the significance of raw materials in the production process with regards to productivity analysis as proposed by the OECD (2001) and has continued to be a main feature in many studies (Burki & Terrell, 1998; Ali, 2007; Aedo *et al.*, 2011; Shamsudin *et al.,* 2013; Lakner *et al.,* 2013)

2.3.4. Capital Input: Measurement and Suitable Proxies

The measurement of Capital input has always been a subject of extensive debate. Taymaz and Saatci (1997) argues that there are four alternatives to measuring capital input: the number of machines installed, total horsepower of installed equipment, depreciation allowances and book value of fixed assets. They argued that none of the proxies could be said to perfectly represent capital stock. Harper (1997) noted that the measurement of capital in productivity literature is limited to equipment, structures, land and inventories. Unlike land, equipment and structures are capital goods which are both reproducible and depreciable and whose cost can easily be determined. Land on the other hand is a fixed asset which does not depreciate but can be traded on the rental market among economic agents and therefore should be treated in similar manner as equipment and structures (Harper: 1997). Many recent studies (Han & Kim, 2001; Din *et al.*, 2007 and Gebreeyesus, 2008) have combined depreciation costs with rental income from land, residential and non-residential buildings as well as from machinery and equipment while others like Bonfiglio (2006) have used depreciation and interest payment as proxy for capital stock.

This analysis tested three different proxies for capital stock namely energy, energy plus payments for repairs and maintenance work done by others on the firm's fixed assets, and depreciation allowances. Except for depreciation allowances, energy and repairs and maintenance are treated as intermediate inputs which relate to expenditures on capital stock in the standard production function (OECD: 2001). Therefore, in the absence of a standard measure of capital input such as depreciation, we seek to choose from the two alternative measures as proxy for capital.

Capital1(Depreciation): Depreciation is a cost allocation process which does not necessarily reflect the market value of an asset and according to the Economic Census Manual (CSO: 2012), a straight-line depreciation method was used to estimate depreciation costs for our dataset. Therefore, it is possible to have a zero depreciation allowance even when the firm has some form of equipment. Table 3 shows that there were 27 firms that had zero depreciation allowances and had to patch them before the estimation. The average depreciation was ZMW 832,115 with a standard deviation of ZMW 5,380,221. Examination of the depreciation variable revealed that:

1. The share of depreciation allowances in gross output was highly unexplainable as most firms' depreciation costs exceeded gross output by more than 100 percent in certain cases

2. The depreciation allowances included structures (residential and non-residential buildings) and land whose annual appreciation is difficult to evaluate given that the rental market in Zambia is virtually non-existent. Despite having a fairly elaborate system of capital allowances (http://taxsummaries.pwc.com/uk/taxsummaries/wwts.nsf/ID/Zambia-Corporate-Deductions), the dataset revealed that there was something fundamentally wrong with the calculations.
3. The values of the given depreciation allowances were highly inconsistent such that one cannot make any economic sense of them.

Capital2(Energy): The variable had 8 missing observations which we patched and gave a mean of ZMW 416,264 with ZMW 2,704,353 standard deviations.

Capital3(Electricity + Fuel + Repairs & Maintenance): The third proxy was the cost of energy plus the cost of repairs and maintenance which had 7 missing observations. After patching, the average was ZMW 500,871 with a standard deviation of ZMW 2,808,098.

Table 1: Variables Defining Efficiency

Variable Name	Measurement	Complete	Missing/ Patched	Mean	SD[1]
Gross Output (ZMW)[2]	Sales + Receipts	115	Nil	18,136,845	17,579,106
Capital1 (ZMW)	Depreciation	88	27	832,115	5,380,221
Capital2 (ZMW)	Electricity + Fuel = Energy	107	8	416,264	2,704,353
Capital3 (ZMW)	Electricity + Fuel + Repairs & Maintenance	108	7	500,871	2,808,098
Labour (Count)	Number of workers per firm	115	Nil	62	301
Materials (ZMW)	Cost of raw materials + changes in stock of raw materials	82	33	11,656,461	70,162,960

1 = Standard Deviation; 2 = Zambian Kwacha (2010 average exchange rate: ZMW/US$=4.80; ZMW/ZAR=0.742)
Source: Census of Economic Activity 2011/2012

Therefore, energy (Capital2) had the least standard deviation relative to depreciation (Capital1) and energy with repairs and maintenance (Capital2). Depreciation allowances had the highest number of patched values which may compromise the integrity of the results. The rest of the analysis is based on the pure technical efficiency and scale efficiency obtained from the Data Envelopment Analysis method using gross output, energy, materials and labour.

2.4.The Tobit Regression Model to Explain Variations in Efficiency

Shamsudin *et al* (2013) and Ali (2007) made no attempt to explain the resulting efficiencies in a regression model, although the vast majority of studies perform model efficiency differences. In Stochastic Frontier Analysis, Battese and Coelli (1995) proposed that the inefficiency model is estimated jointly with the frontier model but it is more common to have a separate inefficiency model. Of course, for Data Envelopment Analysis, it is imperative to have a second stage model since stage one is non-parametric. Often if secondary data is used, these explanatory variables are quite crude, including firm age or operator education, which does not really explain why certain firms do better than others. Alternatively, a series of single variable analysis of variance (ANOVA) tests could be conducted across efficiency categories (Kumar & Arora, 2011; Jeong *et al.*, 2010; Ostertagová & Ostertag, 2013; and Elyasiani & Mehdian, 1995).

The Tobit regression model is a statistical model based on a normally distributed latent random variable (Luoma *et al*: 1998) and has been applied by various researchers to establish the factors affecting firm efficiency in different sectors. For example, Kumar and Arora (2011) used the Tobit regression model with Data Envelopment Analysis efficiency scores as the dependent variable to analyze the technical efficiency of the sugar industry in Uttar Pradesh. The authors established that public ownership has a negative effect on the operating efficiency of the firms. Hwang and Oh (2008) investigated the effect of the existence of Intellectual Property Rights (IPRs) on the efficiency of the software firms in South Korea. The authors applied the Tobit model and established that performance was higher in firms which had some kind of Intellectual Property Rights (IPR) than those that had none. Other authors who have applied the Tobit regression model with DEA efficiency scores as the dependent variable include Fethi *et al* (2000) whose research in European airlines established that concentration and subsidy policies negatively impact the performance of European airlines, Luona *et al* (1998) who explored the productive efficiency of Finnish health centers and showed that higher central government grants and taxable income per person were responsible for inefficiency, Bonfiglio (2006) whose study on the efficiency and productivity changes in the Italian Agri-food cooperatives established that sector size, technology and structural elasticity are responsible for good performance of cooperatives. Still many others (Rezitis & Kalantzi, 2015; Burki & Terrel, 1998) have applied the model to establish determinants of firm efficiency in the agro-processing industry.

The model is suitable for this study because it is a censored model and the Data Envelopment Analysis efficiency scores are censored in that they lie between 0 and 1, implying that the dependent variable (Data Envelopment Analysis efficiency scores) is a limited dependent variable (Tripathy *et al*: 2009). The model is specified as;

$$y = \begin{cases} y^*; & 0 \leq y^* \leq 1 \\ 0; & y^* \leq 0 \\ 1; & 1 \leq y^* \end{cases}$$

$$y^* = \beta x_i + \varepsilon_i; \qquad \varepsilon_i \sim \mathrm{N}(0, \sigma^2)$$

where y is the output-oriented Data Envelopment Analysis pure technical efficiency scores and $y^*$is a latent, unobservable variable; β is a vector of unknown parameters determining the relationship between the latent variable and the independent variables; x_i is a vector of variables determining efficiency. In this study, we use the left censored Tobit regression model.

2.4.1. Variables Explaining Variations in Firm Efficiency

In determining the correlates of firm efficiency, the study relied on existing literature and availability of data. Table 2 gives a summary of explanatory variables used in this study. They include the size of the firm, firm concentration, firm location, technology and type of product.

The variable firm size was split into three dummy variables namely, large, medium and small scale firms. The large scale firms' category was treated as the reference group. In the "noisy" selection theory, Jovanovic (1982) argued that large scale firms are more efficient than smaller firms and therefore are more likely to grow and survive overtime than the small firms which are more likely to stagnate and exit the industry. The theory assumes that firms learn about their efficiency as they operate in the industry and the differences in firm size is therefore not a result of capital fixity, but that, some firms discover that they are more efficient than others. Lundvall and Battese (2000) investigated this relationship and confirmed that there is a positive correlation between firm size and technical efficiency for the Kenyan manufacturing firms with large scale firms exhibiting high efficiency levels than the medium and small scale firms. Bhandari and Ray (2007) also confirmed the positive correlation between firm size and technical efficiency for the textile industry in India. However, in his examination of the duration of small firms' survival in Southern Africa, McPherson (1995) found that the relationship differs across countries. He discovered that in Swaziland and Botswana, the size of the firm had no significant effect on firm efficiency and the firm's chances of survival as opposed to firms in Zimbabwe where the relationship was positive and consistent with the theory. To date this positive relationship has not been investigated in Zambia.

Table 2: Explanatory Variables for Use in the Tobit regression model

Classification	Variables	Description	Hypothesis
Dependent Variable: DEA efficiency Scores			
Independent Variables:			
Firm Size	Large Scale firms (omitted variable)	$\begin{cases} = 1, & if\ employees \geq 50\ workers \\ = 0, & Otherwise \end{cases}$	+
	Medium Scale firms	$\begin{cases} = 1, & if\ employees\ 11 < workers < 49 \\ = 0, & Otherwise \end{cases}$	?
	Small Scale firms	$\begin{cases} = 1, & if\ employees \leq 10 \\ = 0, & Otherwise \end{cases}$	+
Type of Product	Milling	$\begin{cases} = 1, & if\ firm\ is\ in\ Milling \\ = 0, & Otherwise \end{cases}$	?
	Bakery	$\begin{cases} = 1, & if\ firm\ is\ in\ Bakery \\ = 0, & Otherwise \end{cases}$	?
	Meat processing	$\begin{cases} = 1, & if\ firm\ is\ in\ Meat\ Processing \\ = 0, & Otherwise \end{cases}$	?
	Other agri-food (omitted variable)	$\begin{cases} = 1, & if\ firm\ is\ in\ Other\ Agrifood \\ = 0, & Otherwise \end{cases}$	?
Market Share	Market Share	$S_{ij} = f_{ij}/\Sigma F_j\ ; i = 1,2, \ldots, n_j; j = 1,2, \ldots\ldots, 15$ $where\ f_{ij}\ is\ the\ output\ of\ firm\ i\ in\ the\ jth\ sector;\ \Sigma F_j\ is\ total\ output\ of\ the\ jth\ sector$	+
Average Wage	Labour Cost	The ratio of total remuneration and number of employees per firm; $remuneration/workers$	+
Firm Location	Central (omitted variable)	$\begin{cases} = 1, & if\ firm\ located\ in\ Central\ region \\ = 0, & Otherwise \end{cases}$	+
	Northern	$\begin{cases} = 1, & if\ firm\ located\ in\ the\ Northern\ region \\ = 0, & Otherwise \end{cases}$	+
	Western	$\begin{cases} = 1, & if\ firm\ located\ in\ the\ Western\ region \\ = 0, & Otherwise \end{cases}$	−
Technology	R & D	$\begin{cases} = 1, & if\ firm\ spends\ on\ R\ \&\ D \\ = 0, & Otherwise \end{cases}$	+
	Staff Training	$\begin{cases} = 1, & if\ firm\ spends\ on\ training \\ = 0, & Otherwise \end{cases}$	+
	Foreign labour	$\begin{cases} = 1, & if\ firm\ employee\ foreign\ labour \\ = 0, & Otherwise \end{cases}$	+

The effect of spatial distribution of the firms on efficiency was determined by dividing the ten provinces of Zambia into three regions; Central, Northern and Western regions each comprising three provinces except for Central region which was allocated four provinces. The Central region comprise Lusaka, Central, Copperbelt and Eastern provinces while the Northern region has Luapula, Muchinga and Northern provinces, and the Western region has Southern, North-Western and Western provinces. These have been treated as dummy variables with the Central region being the omitted category as it is expected to exhibit the highest level of firm efficiency because it is the most economically active region in Zambia. The argument is supported by McPherson (1995) who empirically established that firms operating in developed locations or regions stand a better chance of surviving and growing to become large scale enterprises because of their proximity to markets and areas with higher income levels.

The sector in which a particular firm operates was also considered. Following the four-digit International Standard Industrial Classification Revision IV (ISIC, Rev.4.), the fifteen sectors of the agro-processing industry were grouped into five categories namely milling, bakery, meat processing, beverages and other agri-food. This was because other sectors had very few sampled firms like in the sugar industry where only one firm had complete data despite the sector having three active firms. The reference group was the “other agri-food” category. The labour cost is taken as the average cost per employee and is assumed to have a positive effect on firm efficiency. The dummy variables R&D and staff training are meant to establish the effect of R&D and staff training expenses on the performance of the firm while foreign labour defines firms with foreign employees and how that would affect firm performance.

The market share was calculated by first adding up firm outputs in respective sectors to get the total output of individual sectors. Then each firm’s turnover was divided by the respective sector total turnover to get the firm’s market share in that sector of the agro-processing industry. Hall and Vopel (1996) used firm sales in their study of explaining the importance of large scale firms in innovation to calculate the market share. The study found that the market value of innovative activity as measured by R&D expenditures was higher for firms with a higher market share in their respective sectors of manufacturing.

2.5.Data Source

In 2011 and 2012, the Central Statistical Office of Zambia conducted the country’s first economic census. The census covered 2010 listing of firms and its objectives were; (a) to measure the value added (GDP) of the Zambian economy, (b) to provide data which would enable the CSO to compile a full set of national accounts, (c) to measure the true extent of both foreign and domestic investment in Zambia, (d) to provide a basis for setting up comprehensive Balance of Payments (BoP) statistics and (e) to provide a basis for the production and rebasing of different kinds of economic statistics (CSO: 2012). The census was carried out in two phases involving the listing and enumeration of enterprises. The listing phase provided the sampling frame for the enumeration phase and covered all enterprises at shopping malls, stores in markets, enterprises with built permanent structures, enterprises operating in containers as well as commercial and large scale farms. The enumeration phase covered 100 percent of the large and medium scale enterprises and only ten percent of the small scale enterprises. According to the economic census manual (CSO: 2012), large scale firms were those whose annual turnover was more than ZMW800, 000 (US$167,000) while medium scale firms were classified to have annual turnover of between ZMW250, 000 and ZMW800, 000 (i.e between US$52,000 and US$167,000). The small scale firms were classified as having annual turnover of less than ZMW250, 000 (US$52,000). Despite the noticeable data concerns related to this study, the Central Statistical Office remains the most credible source of secondary data in Zambia. The 2011/2012 economic census was extensive with an elaborate sampling procedure as well as an exhaustive questionnaire, all of which give credibility to the quality of the data collected. The data collection was based on 2010 financial year before Zambia rebased its currency in 2012 by removing three zeros. Therefore, all monetary values in this study have been converted to current terms (i.e have been divided by 1000).

For this study, we have redefined firm size according to the number of workers the firm employs. Following Biggs and Raturi's (1997) classification of firm size, we define small scale firms as firms with not more than 10 employees, medium scale firms to be firms with 11 to 49 employees while large scale firms as firms with more than 50 employees. The reclassification of firm size from firm output to number of workers is also consistent with the theory of production in that firm output is not a function of firm size but of technology. Therefore, it is possible to have small scale firms and medium scale firms producing much higher outputs than medium and large scale firms respectively depending on their technological efficiencies. Thus, firm turnover is not such a good proxy of firm size especially in efficiency studies such as this one.

Data on the agro-processing industry was extracted from the main manufacturing frame and comprised of 174 firms covering all ten provinces of Zambia and all firm sizes as defined by the central statistical office. However, after accounting for inconsistencies, non-responses and incomplete firm observations, the sample was reduced to 115 firms which is the sample size for this study. The sample size is adequate to warrant the application of Data Envelopment Analysis methods as it satisfies the two necessary conditions proposed by Cooper *et al* (2007). According to Cooper *et al* (2007), the dataset must satisfy the following two conditions:

a. The sample size should be greater than or equal to the product of inputs and outputs i.e $n \geq X \times Y$; where n = Sample Size, X = Number of Inputs and Y = Number of Outputs

b. The number of observations (n) in the dataset should be at least three times the sum of Input and Output variables

i.e $n \geq 3(X + Y)$

Therefore, the minimum sample size for the one output and three inputs specification should be twelve observations.

CHAPTER3: RESULTS AND DISCUSSION

3.1.Growth Opportunities for Zambia's Agro-Processing Industry

The agro-processing industry in Zambia dominates manufacturing and its performance depends on both good agricultural performance downstream and strong demand upstream. This section argues that Zambia has a high agricultural potential and that domestic and export demand for food and beverage products from Zambia are strong.

Despite the declining share of agriculture in GDP (Figure 1, Introduction), the sector enjoys favorable climate conditions with plenty of arable land. It has been estimated that 55 percent of the 75 million hectares of land is suitable for agricultural production which is characterized by a low population density of 21 persons per square kilometer with 59.5 percent of the population residing in rural areas (Deinenger & Olinto, 2000; WDI, 2016). As a result, Zambia has comparatively cheap labour due to the large rural population. According to the 2014 Labour Force Survey (CSO:2014[b]) report, 48.9 percent of all employed persons are in the primary sectors of agriculture, forestry and fishing compared to 3.8 percent in the manufacturing sector. The report also indicates that Zambia has a low skill base in agriculture which has a bearing on the productivity and efficiency of the sector. This is because the large portion of workers in the sector have no formal education. For example, 15.7 percent of the persons employed in agriculture have had no formal education while 50.1 percent have only reached primary level and a further 32.2 percent have been to secondary school (CSO:2014[b]). This means that only 2 percent of the people employed in agriculture have got some form of tertiary education. It also means that agro-processing led industrialization of rural areas is feasible given the close proximity to input factors in agriculture and relatively cheap labour.

Although the share of employment in agriculture has significantly reduced from 71.3 percent in 2008 to 48.9 percent in 2014, the migrating farm workers are not ending up in manufacturing but in the retail and social services sectors which are neither dynamic nor technologically competitive. The share of employment in manufacturing has only seen a marginal increase of 0.3 percent from 3.5 percent in 2008 to 3.8 percent in 2014 compared to that of the wholesale and retail trade which has increased to 11.8 percent from 9.2 percent in 2008 while that of the community, social and personal services sector has risen to 17.4 percent from 8.4 percent.

The food and beverage industry has also a well-established domestic and international market driven by the rising incomes, population growth and urbanization (UNDESA, 2011; UNDESA, 2006). According to the UNDESA (2011) report, the world population is estimated to reach 9.5 billion by 2050 with 96.5 percent of population growth taking place in developing countries like Zambia. Zambia's population has been projected to reach 27 million by 2035 from the current 15.4 million in 2015. These trends coupled with a strong increase in urbanization combined with rapidly changing lifestyles is likely to put pressure on the supply of packaged and processed food products.

The World Bank (2015[a]) estimated in 2010 that more than two thirds of Zambia's national consumption expenditure of US$ 4.12 billion was spent on food and housing, with the expenditure on food twice as high as that on housing. This situation applies to the rest of sub-Saharan Africa, except for South Africa, where food comes third after housing and energy, and Swaziland, where food comes second after housing. Expenditure patterns vary by rural/urban status, with the urban population spending more on food across all income groups than the rural population except for the lowest income households in rural areas whose expenditure is higher than the lowest urban households as shown in Table 3. Furthermore, food represents as much as 58 percent of the lowest quartile's expenditure in Zambia. The low and middle income households spend 40 percent and 27 percent respectively on food and even for the highest income quartile, this figure is still 15 percent (World Bank: 2015[a]). Zambia's population grew by just over 1 percent per annum in the period between 2000 and 2014, but this was accompanied by significant rural-urban migration which resulted in a 7.9 percent per annum increase in the urban population and a 2.4 percent decrease in the rural population (World Bank: 2015[b]). More people in urban areas imply less food self-sufficiency and a growing market demand for staples such as maize and cassava. Global and regional supermarkets like Spar, Pick and Pay and Shoprite emerged to meet this growing demand, as well as the increased demand for quality and freshness of the growing middle classes (Deloitte: 2015). For example, Shoprite first entered the Zambian market in 1995 and has since established 26 branches country-wide, while Pick and Pay which only arrived in 2010 currently has six stores (Fassehaie *et al.*, 2015; Dave *et al.,* 2004; Jonathan & Bruce, 2011). Given their regional reach, the question is whether these companies simply distribute processed foods from South Africa and the rest of the world, or whether food prices can at all be affected by the performance of the agro-processing industry in Zambia itself. The trend is similar for the vast majority of the countries in Sub-Saharan Africa with growing expenditures of the middle class (low & middle categories) society on food and beverages as incomes increase and urbanization rates remain positive (Fassehaie *et al*: 2015).

Table 3: Final Household Consumption Expenditure on Food and Beverage by Income Group and Area (2010, US$ Million)

Country	Area	All	Lowest	Low	Middle	Higher
Zambia	National	2,998.60 (49.4%)	2,148.23 (58.1%)	661.46 (9.7%)	184.45 (27.3%)	4.46 (15.2%)
	Rural	1,254.44 (64.2%)	1,198.23 (65.5%)	55.24 (46.3%)	0.84 (19.6%)	0.14 (27%)
	Urban	1,744.16 (42.4%)	950.00 (50.9%)	606.22 (39.1%)	183.62 (27.4%)	4.32 (15%)

Note: Figures in parenthesis indicate the Percentage Shares of Total Household Expenditure on Food & Beverages

Source: World Bank Global Consumption Database, retrieved from http://datatopics.worldbank.org/consumption/detail, accessed December 2015.

There are export opportunities too. Trade statistics show that the agro-processing sector has experienced increasing export volumes since 2000 as more and more new firms continue to enter the export market to meet the growing regional demand (Sutton & Langmead: 2013). The export growth rates have increased on an annual basis for the past fifteen years ranging between 13.6 percent for the milling sector and 54.4 percent for the cocoa industry. The cocoa sector has shown the most remarkable growth in export value. It is up from US$1,613 in 2000 to US$1,084,522 in 2014. Fruit and vegetable exports are also strong. This sector has grown at an annual rate of 45.4 percent over the same period. Despite a significant drop in exports in 2005 attributable to an outbreak of foot and mouth disease, exports in the meat processing sector grew from US$16,177 in 2000 to US$302, 601 in 2014 (Sinkala *et al*: 2014). Exports of beverages, spirits and vinegar have also increased in the last fifteen years from US$599,469 in 2000 to US$14,100,406 in 2014 with the main export destinations being the Democratic Republic of Congo (DRC) and Zimbabwe accounting for 34.7 percent and 47.1 percent of total beverage exports respectively. The largest food export commodity is sugar whose exports have grown by nearly sixteen percent and recording trade surpluses for the past fifteen years consecutively. The export value has grown from US$24.3 million to more than US$221.5 million with 99.8 percent of total exports destined for the Sub-Saharan African in 2014. The huge increase has largely been driven by the increased investments in production by the three firms operating in the sector (Sutton & Langmead: 2013).

Imports of food and beverage products have more than doubled in the same period except for the sugar and sugar confectionary as well as milling products. This is suggestive of the fact that domestic demand for food products has been on the rise and domestic supplies are not sufficient enough to meet the growing demand. The annual import growth rates vary from 5.7 percent for processed meat to 20.1 percent for beverages. Imports of milling products declined between 2013 and 2014 because of the bumper harvest of maize grain the country recorded which was attributed to the restructuring of the farmer input support program (FISP) by the government among other policies as well as the favorable weather conditions (Kuteya & Sitko., 2015; Fassehaie *et al.,* 2015). Beverages, which include alcoholic and non-alcoholic drinks, imported US$2,448,088 in 2000. Thereafter, imports grew at an annual growth rate of 20.1 percent to reach US$38,082,122 in 2014. In 2014, Zambia imported 73.6 percent of beverage products from South Africa. Unlike alcoholic beverages, imports of non-alcoholic beverages have witnessed a significant decline since 2010 as more and more local firms continue to enter into the industry to try and meet the domestic demand.

The overall trade balance, illustrated in Figure 3, shows that Zambia has been experiencing increasing trade surpluses in the agro-processing industry since 2000 largely driven by exports of milling and sugar products as well as the non-alcoholic beverage products. Figure 3 shows that without accounting for the milling and sugar sectors, Zambia has been facing increasing trade deficits in all sectors of the agro-processing industry (i.e beverages, processed meat, vegetables, cereals, cocoa and other edible products). From US$16.69 million in 2000, the trade deficit has risen to US$93.84 million in 2014. The trade surplus recorded in 2013 was as a result of a once-off exports in beverages of undenatured ethyl alcohol (strength < than 80 %) worth US$ 177 million to the Middle East (Fassehaie *et al*: 2015). Suffice to say that this once-off success does indicate some comparative advantage in this area.

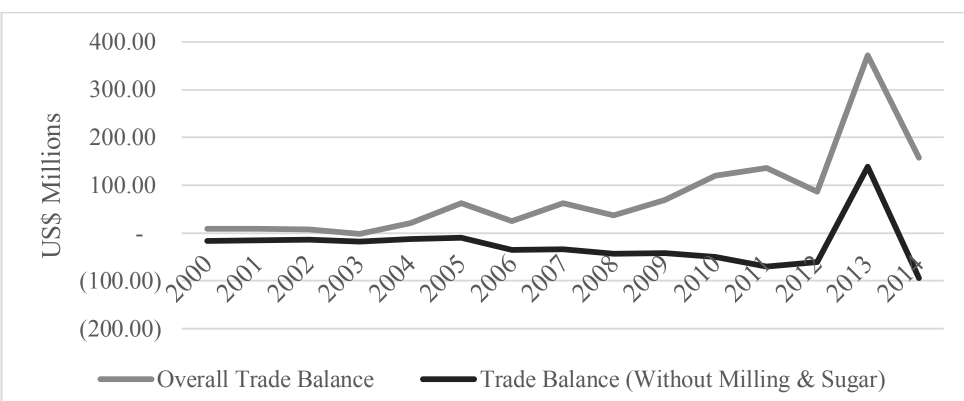

Figure 3: Zambia's Food Trade Balance: With and Without Milling and Sugar sectors
Source: UN Comtrade, retrieved from http://comtrade.un.org/ accessed December 2015.

It is evident that export opportunities exist in the sugar, milling and bakery sectors of the agro-processing industry. The major trading partners include the Democratic Republic of Congo, South Africa, Zimbabwe and Mauritius which accounted for 28.5 percent, 21.2 percent, 17.4 percent and 7.3 percent of total food and live animal exports respectively in 2014. Further opportunities exist in the domestic market where Zambia has been recording increasing trade deficits in sectors such as alcoholic beverages, meat processing, vegetable processing, cocoa products and pastry cooks' products. For example, South Africa accounted for 52.4 percent of food and live animals in 2014 with 16 percent from Namibia and 8.2 percent from Zimbabwe. In the beverages sector, Zambia imported 73.6 percent from South Africa and 18.5 percent from Namibia and exported 47.1 percent and 34.7 percent to Zimbabwe and Democratic Republic of Congo respectively in 2014. The exports of beverages were mostly non-alcoholic while alcoholic beverages accounted for the largest share of beverage imports.

Given these opportunities, it is important to analyze the performance of the firms and the agro-processing industry as a whole so as to establish whether the existing market opportunities are aligned with the capabilities of the firms in these particular markets. If they are, there is reason to be hopeful of agriculture’s contribution to the reindustrialization of Zambia and Africa in general. If not, the government has a responsibility to investigate and take action to relieve the main constraints in the sector.

3.2.The Structure and Efficiency of the Agro-processing Industry

Zambia’s agro-processing industry is dominated by the food sector which accounts for 88 percent of the total number of firms while the beverages sector constitutes a partly 12 percent. When classified according to the number of workers employed, the size distribution of the agro-processing industry is hierarchical with 56 small scale firms representing 48.7 percent of the industry firms at the base of the pyramid. The medium scale firms were 41 (35.7 percent) while at the top of the pyramid were 18 large scale firms representing 15.7 percent of the industry. The large scale firms are only prevalent in five of Zambia’s ten provinces (Lusaka, Southern, Eastern, Northern and Copperbelt) with Lusaka province accounting for 50 percent followed by the Copperbelt province with 33.3 percent and the rest of the provinces accounting for only six percent each. The results further show that the Central region also hosts most of the medium and small scale firms. There were 30 medium scale firms and 28 small scale firms operating in the Central region compared to only 2 medium scale and 15 small scale firms in the Northern region, and 9 medium scale firms with 13 small scale firms in the Western region of the country. Most of these firms are however situated only in Lusaka and Copperbelt provinces which share the same number of the medium scale firms of 26.8 percent respectively with Lusaka province having slightly more small scale firms (14.3 percent) than the Copperbelt province (8.9 percent). The small scale firms are more prevalent in the Eastern province accounting for 19.6 percent of all small scale firms in the industry. The concentration of firms in the Central region (Lusaka, Central, Copperbelt and Eastern provinces) can be alluded to the fact that it is the most urbanized and densely populated region of Zambia (CSO:2013). Using location theory, Krugman (1991) argued that firms tend to concentrate their production centers close to large markets in order to economize on transportation costs, which explains why the sparsely populated regions of Zambia have very few firms operating in them. The theory also partly helps in understanding why large and medium scale firms are non-existent in both Luapula and Muchinga provinces as well as the non-existence of large scale firms in Northwestern and Western provinces.

The bakery and milling sectors dominate Zambia's agro-processing industry with each accounting for 27.8 percent and 27 percent respectively. This is unsurprising as the main ingredient in the preparation of Nsima, the Zambian staple food, is processed in these two categories often by small scale firms. A total of thirty-one firms were recorded in the milling sector with nineteen small scale firms and six medium and large scale enterprises. Unlike the milling sector which is dominated by the small scale firms, the bakery sector is dominated by the medium scale firms. Thirty-two firms were recorded in the bakery sector including seventeen medium sized bakeries (53.1 percent), fourteen small scale firms (43.8 percent) and only one large scale firm (3.1 percent). The meat processing sector accounted for only 7.8 percent of the total firms followed by the vegetables and animal oils sector which constitute 7 percent of the industry firms. Although the meat processing sector is small, it consists predominantly of large scale firms. A total of nine firms from the meat processing sector were sampled and comprised of four large scale enterprises, three medium scale and two small scale firms respectively. Table 3 shows the summary categorization by firm size and sector.

Table 4: Distribution of Firms by Size (Number of Workers) and Sector

ISIC_REV4	Description	Large	Medium	Small	Total
1010	Processing and preserving of meat	4	3	2	**9 (7.8%)**
1020	Processing and preserving of fish, crustaceans & molluscs		1	3	**4 (3.5%)**
1040	Vegetable and animal oils and fats		3	5	**8 (7%)**
1050	Dairy products		1	1	**2 (1.7%)**
1061	Grain mill products	6	6	19	**31 (27%)**
1062	Starches and starch products			6	**6 (5.2%)**
1071	Bakery products	1	17	14	**32 (27.8%)**
1072	Sugar	1			**1 (0.9%)**
1073	Cocoa, chocolate and sugar confectionery		1		**1 (0.9%)**
1079	Other food products n.e.c.	3	2	1	**6 (5.2%)**
1080	Prepared animal feeds		1		**1 (0.9%)**
1101	Distilling, rectifying and blending of spirits	1	2		**3 (2.6%)**
1102	Wines		1		**1 (0.9%)**
1103	Malt liquors and malt	2	3		**5 (4.4%)**
1104	Soft drinks, mineral waters, other bottled waters			5	**5 (4.4%)**
	TOTAL	**49**	**14**	**52**	**115 (100%)**

Source: Economic Census 2011/2012

The industry is highly technically inefficient with an average technical efficiency of 42.5 percent and 81.7 percent scale efficiency. When analyzed in terms of firms that are both technical and scale efficient, technical efficient but not scale efficient and in terms of all technical efficient firms and all scale efficient firms, seven firms were found to be both technical and scale efficient. Among them were six firms from the Central region and one small scale firm operating in the bakery sector from the Western region. The six firms include two large scale firms operating in the milling sector and four medium scale firms each operating in the meat processing, animal feeds, other food products, and vegetable and animal oils sectors respectively. Thirteen firms were found to be technically efficient but not scale efficient while one firm was only scale efficient. This implies that 11 percent of the industry firms employ best technology practices but operate at inefficient scales. Four firms were found to be too large and operating under decreasing returns to scale while the other nine were operating at a very small scale under increasing returns to scale. These are mostly small scale firms (8 small scale firms) located in the Central and Western regions of the country and specialized in grain milling, soft drinks and water, and vegetable oils. Overall, a total of 20 firms (17.4 percent of all industry firms) were found to be technical efficient while eight (7 percent of all industry firms) were scale efficient, implying that 82.6 percent of the firms are operating below the frontier (inefficient) while 93 percent are scale inefficient.

Disaggregating the agro-processing industry into the food sector and beverages sector offers further insight. Compared to the food sector, the beverages sector is relatively more technical efficient but less scale efficient, largely because of the relatively superior technologies associated with the sector. The results show that the beverages sector is 58.7 percent technical efficient but only 78.9 percent scale efficient compared to the food sector which is 40.3 percent technical efficient and 82.1 percent scale efficient. Although the entire industry needs technological improvements, it is clear that the food sector is in worse efficiency situation than the beverages sector which could have a negative impact on the cost of food. This is more so given the fact that the bottom half of the firms in the food sector are only 27.3 percent technical efficient but 91.3 percent scale efficient compared to the beverages sector where the bottom half of the firms are 65.4 percent technical efficient and 93 percent scale efficient. This implies that scale efficiency is not necessarily a big challenge but input utilization which if best practice technologies are adopted, the food sector can be improved upon by 72.3 percent.

Table 5: Descriptive Statistics of Firm Efficiency by Industry

Statistics	**Entire Sector (N = 115)**		**Food (n = 101)**		**Beverage (n = 14)**	
	Technical Efficiency	Scale Efficiency	Technical Efficiency	Scale Efficiency	Technical Efficiency	Scale Efficiency
Mean	0.425	0.817	0.403	0.8205	0.587	0.789
Minimum	0.009	0.03	0.009	0.03	0.052	0.259
Q1	0.137	0.7615	0.134	0.772	0.3065	0.671
Median	0.2935	0.914	0.273	0.913	0.6535	0.9295
Q3	0.677	0.984	0.653	0.984	0.9115	0.9835
Maximum	1	1	1	1	1	0.998

Source: Own Calculations

It can be inferred from the foregoing that the performance of the entire agro-processing industry depends on the efficiency of both the food and the beverages sectors. It is clear though from Table 5 that the efficiency of the food sector has huge implications on the overall efficiency of the industry. For example, the top twenty-five percent (Q3) of the firms in the food sector are 65.3 percent technical efficient and 98.4 percent scale efficient which are a very close reflection of the efficiency levels of the top twenty-five percent firms of the entire industry with technical efficiency of 67.7 percent and scale efficiency of 98.4 percent. The case is similar for both the bottom twenty-five percent (Q1) and for half of the firms in the food sector whose efficiency levels are hardly different from those of the overall industry efficiency. Therefore, improving the performance of the food sector would generally be beneficial to the entire agro-processing industry.

Scale and technical efficiency are inversely correlated ($\rho = -0.3182$, P-value = 0.0005). This means that large scale firms tend not to be technical efficient but scale efficient, while small scale firms tend not to be scale efficient but do better in terms of technical efficiency. The exceptions are firms 4, 15, 28, 29, 75, 99 and 101 which are both technical and scale efficient. Firm 4 is a medium scale firm operating in the meat processing industry in Kafue district of Lusaka province and employs 45 workers at an annual average cost of ZMW55,369 per worker. Located in Lusaka is firm 15, a vegetable and animal oils company that employs 30 persons to generate an annual turnover of ZMW10,400,000 in sales and receipts. This firm's average wage is ZMW2,500 per worker, which is quite low compared to firms in other sectors of the agro-processing industry. Firms 28 and 29 are both large scale firms in grain milling sector. Firm 28, located in Chipata district of Eastern province, employs 867 workers at a much higher average wage of ZMW 26,975 per worker. Firm 28 has an annual turnover of ZMW 258,864,271. Firm 29 is based in Lusaka province, employs 103 workers and pays them ZMW 13,112.98 per worker per year. Firm 75 is a small scale firm in Kabompo district of North-Western province which employs only 10 workers costing ZMW 1,970 per employee to produce a turnover of ZMW834,576 in sales and receipts. Firm 99 is a medium scale firm in Kalulushi district of the Copperbelt province with 28 workers costing ZMW1,199 per worker while firm 103 is also a medium scale firm located in Lusaka province and operating in the animal feeds sector.

These data suggest that there is no easy way of determining efficiency in the agro-processing industry. Therefore, the next section will systematically check for differences across firm size, the urban-rural divide, and industry subsectors.

3.3.Correlates of Firm Efficiency

The results from the analysis of variance presented in Table 6 show that the sector within which an individual firm operates is a huge factor on scale efficiency but not so much on average technical efficiency as revealed by the P-values 0.0926 and 0.1611 respectively. The result is similar to the findings of Aedo *et al* (2011) who in his study of the Chilean agro-processing industry established that the sectors of the agro-processing industry had no effect on the firm's technical efficiency. In Zambia, the two largest sectors (Milling and bakery) are the most inefficient of the agro-processing industry. The consequence of this scenario on the market is often reflected in uncompetitive high prices of milling and bakery products which are a larger component of Zambia's staple meal. The milling firms in the Western region happen to be the most technical inefficient averaging 24.3 percent with more than sixty percent of them operating below 15 percent of technical efficiency. The Northern region is second at 27.4 percent and as expected, the Central region is the most relative technical efficient in the milling sector with an average efficiency of 46.2 percent. The results are quite different in the bakery sector where firms in the Central region are the most inefficient with an average technical efficiency of 28.8 percent followed by the Northern and Western regions at 37.7 percent and 45.0 percent respectively. Skills training is an obvious remedy especially where technical efficiency is low. Any investment that would lower the cost of doing business should also improve efficiency.

The bakery sector is the most scale efficient averaging 90.9 percent followed by the meat processing, beverages, milling, and other agri-food sectors. This implies that firms operating in the bakery sector are good at optimizing on the economies of scale especially that more than half are located in the Central region with Lusaka, Copperbelt and Southern provinces accounting for the most. The bakery firms in the Northern region are marginally more scale efficient than those in the Central region with scale efficiency of 95.6 percent and 95.1 percent respectively. The Western region is the least with relative scale efficiency of 81.2 percent.

The results from the analysis of variance also show that efficiency is significantly different across firm sizes. The small scale firms are the least technical efficient followed by the medium and large scale firms while the medium scale firms are the most scale efficient followed by the large scale firms and small scale firms respectively. While large scale firms are 69 percent and 82.3 percent technical and scale efficient respectively, the medium scale firms are 40.5 percent and 97 percent, and the small scale firms are 35.4 percent and 70.2 percent technical and scale efficient respectively. The results are consistent with Jovanovic's (1982) selection theory wherein he argues that efficiency increases with firm size, a theory that has been confirmed by many authors in different settings (Lundvall & Battese, 2000; McPherson, 1995). The small scale firms located in the Central region are technically more efficient averaging 43.3 percent than those in Western and Northern regions whose average efficiency is 36.4 percent and 19.8 percent respectively. Therefore, small scale firms are more likely to do well in Central Zambia than in both Western and Northern.

The location of the firm is only significant for technical efficiency which leads to the rejection of the hypothesis that there is no difference in the relative technical efficiency across regions. As expected, the Central region has the most technical efficient firms relative to Western and Northern regions. This is consistent with the findings of both Bonfiglio (2006) and McPherson (1998) who established that firms located in developed regions of the country are likely to be more efficient than those in less developed regions. The reasons for such differences are many and in the case of Zambia, the results show that proximity to the market outweighs the disadvantages associated with competition to which the firm is exposed. Firms that operate in concentrated regions have also an advantage of optimizing on transportation costs which are relatively lower than in regions that are not concentrated (Krugman:1991).

Table 6: Summary of ANOVA Results (Sector, Firm Size, and Region)

Variables	***N***	***Technical Efficiency***	***Scale Efficiency***
		Sector	
Bakery	32	0.3493	0.9087
Beverages	14	0.5868	0.7893
Milling	31	0 .3753	0 .7750
Meat Processing	9	0 .5426	0 .8761
Other Agri-food	29	0.4469	0.7545
	F-Statistic	**1.67 (0.1611)** ⱡ	**2.05 (0.0926)** *
	Firm Size (Number of Workers)		
Large Scale firms	18	0.6904	0.8227
Medium Scale firms	41	0.4051	0.97
Small Scale firms	56	0.3543	0.7025
	F-Statistic	**7.45 (0.0009)** ***	**18.17 (0.0000) ***
		Region	
Central	74	0.4929	0.7951
Northern	18	0.2193	0.8966
Western	23	0.3675	0.8234
	F-Statistic	**5.43 (0.0056) ***	**1.24 (0.2925)**

*** Significant at 1%, ** Significant at 5%, * Significant at 10%, ⱡ Significant at 20%
Note: P-values in parentheses
Source: Own Calculations

The results in Table 7 are from three left censored Tobit regression models which were run to avoid using too many variables on a small sample size (overfitting) and collinearity. The first two were to identify significant variables to include in model III. Model I considered the influence of firm size, firm location and market share on both technical and scale efficiency while Model II specified the influence of the sector, labour costs and expatriate labour (foreign labour) on technical and scale efficiency.

The dummy variables R&D and staff training were dropped to improve the goodness of the model using AIC information criterion as proposed by Akaike (1973). The variables also revealed that there is very little effort aimed at R&D and capacity building in the industry with only four of the 115 sampled firms involved in R&D activities with an average annual expenditure of ZMW 31,019 while another eight firms had some form of staff training program with an average annual budget of ZMW19,166. With these levels of investments in research and capacity building, it is difficult for the agro-processing industry in Zambia to be technologically dynamic and increasingly adaptive to the ever changing business environment in the food economy.

The firms involved in R&D were firms 15, 37, 97 and 104 with an average technical efficiency of 39.9 percent and mean scale efficiency of 88.7 percent. Firm 15, a medium scale firm located in Lusaka district and operating in the vegetable and animal oils sector was both technical and scale efficient (technical and efficiency score of 1) with constant returns to scale while firm 37 was the least technical efficient (7.2 percent technical efficiency) of the four firms and the only small scale firm involved in R&D with a scale efficiency score of 92.5 percent. The firm is located in Kabwe district of Central province and is involved in the manufacture of grain mill products. Firm 97 is a large scale firm situated in Kitwe district of the Copperbelt province and is the only firm that invests in both R&D and staff training activities. The firm is experiencing decreasing returns to scale with scale efficiency 67.7 percent and technical efficiency of 41.2 percent while firm 104 is a medium scale firm in Lusaka involved in distilling, rectifying and blending of spirits. The firm is only 11.1 percent technical efficient but 94.4 percent scale efficient. From the foregoing, it is clear that investments in R&D have only focused on the exploitation of the economies of scale by optimizing the scale of their operations but not on the production technologies employed. The case is similar even for firms (firms 3, 29, 30, 61, 94, 95, 97 and 101) which invest in capacity building activities through staff training as they are only 62.6 percent technical efficient but 89.9 percent scale efficient with most of them located in Lusaka and Copperbelt provinces. Much as scale efficiency is important, there is need for firms to focus their investments in R&D and staff training on improving production technologies that would enhance technical efficiency and reduce the wastage of input resources. Such strategies would have positive implications on the retail prices of the food and beverage products both in the short run and long run.

The Tobit regression results in Table 7 affirm the claim that technical efficiency is significantly influenced by firm size, market share, labour costs, and firm location in different proportions. Relative to large scale firms, medium scale firms are 14.3 percent more scale efficient while small scale firms are 17.1 percent less scale efficient. This implies that the challenge for medium scale firms is not scale efficiency per se but improving on technical efficiency while small scale firms are faced by both low technical and scale efficiency.

The high inefficiency levels prevailing amongst small and medium scale firms partly explains the industry's stagnation. The growth of the sector largely depends on a well nurtured and competitive small scale segment which is not the case for Zambia where entry costs remain prohibitive (Lundvall & Battese, 2000; Doing Business, 2016). Lundvall and Battese (2000) argued that large scale firms are often more likely to benefit from reliable input sources which have been established over time, consumer awareness of the existence of the firm and its products as well as from the economies of scale but small scale firms do not have the luxury of such advantages and are therefore exposed to more competition. Much emphasis is placed on the nurturing of small scale firms because small scale firms are less likely than their large scale counterparts to be caught up in regulatory red tape and to be adversely affected by a domestic skills shortage (Lundvall & Battese, 2000; McPherson, 1995). As firms transition from small through medium to become large scale firms, the demand for skills, technological knowledge and process development tend to increase (Morris *et al*: 2012). Therefore, the failure by the domestic systems to effectively harness and supply the required skills by offering relevant quality education and training would negatively impact the transitioning process of the small scale firms. This is because either option of employing expatriates or domestic human resource would result in higher labour costs or a compromise on managerial efficiency (Morris *et al*: 2012).

Table 7: Tobit Regression Results

Explanatory Variables	Dependent Variables: Technical Efficiency	Scale Efficiency
Model I		
Medium Scale Firms	-0.224 (0.088) ***	0.143 (0.058) **
Small Scale Firms	-0.187 (0.091) **	-0.171 (0.0605) ***
Market Share	0.341 (0.131) ***	0.032 (0.086)
Northern Region	-0.231 (0.084) ***	0.223 (0.055) ***
Western Region	-0.058 (0.074)	0.066 (0.049) Ɨ
Constant	0.599 (0.083)	0.797 (0.055)
Log Likelihood	-25.239	22.328
Pseudo R2	0.357	15.413
Prob > chi2	0.000	0.000
Model II		
Bakery Sector	-0.057 (0.080)	0.171 (0.059) ***
Milling Sector	-0.020 (0.082)	0.046 (0.06)
Meat Processing	0.054 (0.119)	0.098 (0.088)
Beverages Sector	0.132 (0.102)	0.021 (0.075)
Average Labour Cost	0.000 (0.000) ***	0.000 (0.000) *
Foreign Labour (Dummy)	0.065 (0.078)	0.098 (0.057) *
Constant	0.343 (0.064)	0.704 (0.047)
Log Likelihood	-28.905	5.976
Pseudo R2	0.264	4.858
Prob > chi2	0.002	0.020
Model III		
Medium Scale Firms	-0.215 (0.087) **	0.13 (0.059) **
Small Scale Firms	-0.163 (0.091) *	-0.148 (0.062) **
Market Share	0.208 (0.149) Ɨ	
Bakery Sector		0.156 (0.058) **
Northern Region	-0.207 (0.08) ***	0.214 (0.053) ***
Average Labour Cost	0.000 (0.000) *	0.000 (0.000)
Foreign Labour (Dummy)		0.0398 (0 .053)
Constant	0.541 (0.085)	0.762 (0.059)
Log Likelihood	-23.752	24.615
Pseudo R2	0.395	16.889
Prob > chi2	0.000	0.000

*** Significant at 1%, ** Significant at 5%, * Significant at 10%, Ɨ Significant at 20%

Note: Numbers in parentheses are asymptotic standard errors

The Tobit regression results suggest that Zambia lacks the necessary skills to enable small scale firms in the agro-processing industry to grow into medium and large scale firms. There are only a few firms involved in technologically demanding sectors such as dairy products, sugar, cocoa and chocolate confectionaries in which Zambia has comparative advantage over other Southern African countries. We also see high inefficiency levels amongst small scale peri-urban firms which is consistent with the findings of Fassehaie *et al* (2015). The failure by the firm to adopt new technologies and skills as it transitions to become large scale would offset the efficiency gains achieved in its lifespan (Jovanovic, 1982; Burki and Terrell, 1998). Therefore, having a large segment of efficient small scale firms is important to Zambia and would serve as a base for young entrepreneurs if managed properly. Lundvall and Battese (2000) argued that expansion of small scale segment of the industry would result in more efficient allocation of resources, reduce inequality of income distribution and unemployment. This is because small scale firms use more labour intensive technologies than large scale firms. The results further indicate that operating in the Northern and Western regions guarantees scale economies especially for medium scale firms which have a comparative scale efficiency advantage over large scale firms.

In model II, the labour cost variable was found to be statistically significant but with a marginal contribution to both technical and scale efficiency while scale efficiency was found to be further influenced by expatriate labour and the kind of sector a firm operates in. The results also revealed that firms in the bakery sector have significant positive economies of scale averaging 15.6 percent relative to other sectors while expatriate labour can raise the firm's scale efficiency by 9.8 percent. Therefore, building domestic capabilities would enhance scale and managerial efficiency at low costs as they gradually start to take up positions of expensive expatriate labour.

In model III, the size of the firm's market share is an important aspect of firm efficiency and was found to be significant at one percent level and 20 percent with a pairwise correlation ($\rho = 0.326$, P-value = 0.0004) confirming that there is a direct relationship between technical efficiency and the firm's market share. This is to say that the bigger the firm's market share, the more efficient the firm becomes and for every percentage of the market share gained, technical efficiency and firm output is increased by 34.1 percent. The case is different with scale efficiency where it has been established that the size of the firm's market share has no effect. The results are consistent with the findings of Hall and Vopel (1997) who established that technical efficiency is associated with the size of the market a firm enjoys.

The industry is also highly concentrated with a Herfindahl–Hirschman Index (HHI) of 0.37098 which is way above the minimum concentration level of 0.18. This implies that the industry is highly uncompetitive and is characterized by huge firm entry costs averaging 33.6 percent of income per capita compared to South Africa where starting up a business only costs 0.3 percent of income per capita (Doing Business: 2016). High entry costs are a hindrance to the evolution of the industry as they discourage competition to the existing firms. Hopenhayn (1992) pointed out that higher entry costs raise the level of discounted profits necessary to make entry profitable thereby promoting the existence of less efficient as well as less productive firms. The literature shows that entry costs may arise from prohibitive policies and regulations especially if they are dense and unpredictable as the case is in developing countries like Zambia (Gebreeyesus, 2008; McPherson, 1995). Policies such as price controls, rationing of foreign currency and regulations on foreign trade coupled with poor taxation and business licensing laws, policy and political uncertainty may raise the firm entry costs and derail the growth of the industry.

3.4. Dominant Firm Technologies

The peer count allows one to pick from amongst a set of efficient firms, those with the most representative technologies (Conradie and Piesse: 2015). Refining the number of firms to which an efficient firm serves as benchmark to the number for which it serves as main peer, reduces the 19 efficient production systems to six benchmark types. These six firms represent industry benchmarks and include Firms 39, 4, 113, 75, 101 and 28. Firm 28 had the highest peer count but did not serve as the main peer for any of the firms in the industry as defined by peer weights.

Firms 39 and 113 are highly scale inefficient small scale firms based in the Copperbelt and Lusaka provinces with operations in the milling and beverage sectors respectively. They both have one worker with an average labour cost of ZMW 3,600 and ZMW 7,200 which are 66.6 percent and 33.1 percent respectively below the industry average of ZMW 10,765.49. On the other hand, firm 75, a bakery firm in Kabompo district of Northwestern province was both technically and scale efficient. Despite being classified as a small scale firm, firm 75 employed ten workers at even lower wages of ZMW 1,969.6 per year. The firm's labour input was less productive compared to the overall labour productivity average of the bakery sector, but more productive when compared to the rest of the small scale firms within the bakery sector. The implication of firm 75's technology is that the key to increasing the scale of operation especially for small scale firms such as Firms 39 and 113 is to increase the labour force at a reduced average labour cost and improving the productivity levels of the input factors. It is evident from Table 8 that the output produced per unit of materials and energy was below the sector averages for Firms 39 and 113 respectively, except for labour where the output produced per worker was 27 percent above the soft drinks and water sector average for Firm 113.

The large and medium scale firms provide alternative technologies for the rest of the industry. Firm 28 was the most representative large scale firm with a peer count of more than twenty, others were firm 3 with 4 peers, firm 26 with 2 peers, firm 29 with 7 peers, and 9 peers for firms 93 and 106.

Table 8: Benchmark Firms and their Input Productivities

FIRM ATTRIBUTES	**Industry Benchmarks**					
	Small Scale Firms			Medium & Large Scale Firms		
Benchmark Firms	**Firm 39**	**Firm 113**	**Firm 75**	**Firm 28**	**Firm 4**	**Firm 101**
Sector	Milling	Drinks & Water	Bakery	Milling	Meat	Animal Feeds
District (Province)	Mufulira (Copperbelt)	Lusaka (Lusaka)	Kabompo (N/Western)	Chipata (Eastern)	Kafue (Lusaka)	Lusaka (Lusaka)
Firm Size (Number of Workers)	Small (1)	Small (1)	Small (10)	Large (867)	Medium (45)	Medium (24)
% of Firms to which the Benchmark firm serves as a Peer	30.4	25.2	37.4	38.3	71.3	26.1
% of Firms to which the Benchmark firm serves as the MAIN Peer	19.1	14.8	10.4	Nil	16.5	1.7
Too large/Too small for Technology (%)[1]	11.2	28.7	100	100	100	100
Firm Input Productivities at Firm, Sector and Firm Size Levels						
Revenue/Worker (ZMW)	9,600	41,200	83,458	298,575	347,861	737,866
Sector Average (ZMW)	*284,664*	*32,345*	*107,533*	*284,664*	*256,999*	*737,866*
Firm Size Average(ZMW)[2]	*29,717*	*32,345*	*56,255*	*316,511*	*230616*	*737,866*
% difference (Industry vs Size Segment)	*-96.6 vs -67.7*	*27.4*	*-22.4 vs 48.4*	*4.9 vs -5.7*	*35.4 vs 50.8*	*None*
Revenue/Energy Costs (ZMW)	22.9	38.1	188	8491.4	85	110.9
Sector Average (ZMW)	*57*	*77.8*	*16*	*57*	*54*	*110.9*
Firm Size Average(ZMW)	*13.4*	*77.8*	*12*	*62.5*	*104*	*110.9*
% difference (Industry vs Size Segment)	*-59.9 vs 70.6*	*-50.9*	*1069.8 vs 1458*	*14794 vs 1385*	*58 vs -17.9*	*None*
Revenue/Materials (ZMW)	0.0016	2.3	40	1.07	138.4	1.5
Sector Average (ZMW)	*1.2*	*2.4*	*1.3*	*1.2*	*0.02*	*1.5*
Firm Size Average(ZMW)	*0.07*	*2.4*	*1.8*	*1.3*	*2.6*	*1.5*
% difference (Industry vs Size Segment)	*-99.9 vs -97.7*	*-3.3*	*2992.6 vs 2064.6*	*-7 vs -13*	*606303.7 vs 5232.8*	*None*
Firm's Market Share	1.5	11.58	1.5	51.49	12.8	100

1=The level of scale efficiency; 2=Relative to the benchmark firm size & sector

Source: Own Calculations

Firm 28 is a large scale milling company operating in Chipata district of the Eastern Province. The firm is unique because it functions like a cooperative that provides inputs, training and finance to a well-established network of smallholder farmers. Its work helps local families to raise their farming standards, optimize yields and raise household incomes while maintaining a steady supply of maize grains to the firm. The integration of the local smallholder farmers in the supply chain has helped the firm to significantly reduce transaction and transportation costs which are reflected in the competitive retail prices of its products. As a result, the company enjoys a 51.5 percent market share of the milling sector with a workforce of 867 employees at an average labour cost of ZMW 26,975.45 per worker which is 387 percent above the milling sector average of ZMW 6,969.7. The productivity of both the energy and labour inputs is above the meat industry average except for the materials input which is 7 percent less productive. A further comparison among the large scale firms within the milling sector reveals that output produced per unit of materials and labour inputs for Firm 28 was below average. Therefore, while the firm does perform well on the overall sector level, its factor inputs are not as productive compared to similar large scale firms.

Firm 4 is a medium scale butchery company located in Lusaka province. It accounts for 12.8 percent market share of the meat processing sector with a workforce of 45 employees costing ZMW 55,369.3 per worker annually. This amounts to 292 percent above the meat processing sector's annual average labour cost of ZMW 18,981.2 percent. The firm's core business is in slaughtering, processing and distribution of meat products to its retail outlets within Lusaka province where it only operates. The limited presence of the firm reduces the distribution and transportation costs which are an important aspect in optimizing scale economies (Krugman: 1992). It is not surprising therefore, that, the productivity of all inputs is above the sector average. Even amongst its size peers, the materials and labour inputs are more productive except for energy input whose level of productivity is below the average of the medium scale firms segment.

Firm 101 is one of the two main firms operating in the animal feeds sector in Zambia. The firm was established in 1998 and has since grown from three employees to twenty-four in 2010 and to 130 in 2016. Its product line covers feed stocks for beef and dairy cattle, broilers and layer chickens, fish, pigs, sheep and game animals. The key to its good performance is attributable to its lean but highly motivated, well trained and skilled workforce comprising three expatriates with an estimated average annual labour cost of ZMW 116,595.8 per worker. The firm also benefits from its investments in staff training averaging ZMW 11,543 in 2010 which has positive implications on productivity and capabilities of the workforce.

It is evident from the benchmark firms that the main challenge for the industry relates partly to low labour productivity especially with small scale firms. For example, there were a total of four small scale firms (Firms 23, 74, 75 and 78) which had ten employees but only Firm 75 was efficient both in terms technical and scale. It also happens to have the least average labour cost despite operating in the same bakery sector with Firms 74 and 78 except for Firm 23 which is in the dairy sector. This shows that the high average labour costs associated to Firms 23, 74 and 78 are not commensurate to the output levels produced per worker. Even inefficient small scale firms with less than ten workers had higher average labour costs than Firms 39, 113 and 75.

CHAPTER 4: CONCLUSION AND POLICY IMPLICATIONS

4.1.Main Findings

The dissertation set about identifying Zambia's competitive advantage in agro-processing and then studying the productivity of the sector to see if it is likely that the agro-processing sector could lead a program of reindustrialization. Step 1 identified opportunities existing in agro-processing. Step 2 found the sector wanting, at an average technical efficiency of only 42.5 percent. With this efficiency level, it is difficult for the industry to be competitive domestically and on the international market. As a consequence of its low productivity, Zambia has experienced increasing imports of processed food products since 2000, perhaps because of the lack of necessary capabilities needed to meet the high food standards being demanded by the growing middle class society. Meeting these standards require that firms are upgraded and become more dynamic and innovative not only with respect to food quality but also in branding and packaging in order to make the products more appealing to the consumers. Thus, investment in R&D and capacity building are quite critical in the changing food economy. It is problematic that, only 3.5 percent of the firms invest in R&D and another seven percent make investments in capacity building of the staff. Tax incentive schemes should be considered to encourage large scale firms to invest more in these areas.

The beverage and meat processing sectors stand out as the most technical efficient while the bakery sector is the most scale efficient. It has also been established that the beverage sector is dominated by the non-alcoholic beverage producing firms, a subsector which has shown great potential for growth. The 58.7 percent technical efficiency is reflective of the competitiveness of the beverage sector domestically and on the international market which has resulted in the continued reduction of the share of non-alcoholic beverage imports since 2010. Therefore, support towards these two sectors would clearly pay off in terms of the greatest technical efficiency which would result in reduced retail price levels. However, other sectors should as well be considered. Inefficiency is counter development and neglecting the other sectors would only yield an undesirable lopsided development of the agro-processing industry.

The study also showed that performance is a function of firm size with inefficiency associated with small scale firms and efficiency with medium and large scale firms. It has been argued that small scale firms are not only important to industrial growth but also constitute a seedbed for young entrepreneurs whose success guarantees economic development (Jovanovic, 1982; Lundvall & Battese, 2000). Therefore, support aimed at enhancing the performance of small scale firms is critical to the survival and growth of the industry, but ideally, these small scale firms should be linked in with large producers or distributors. Consideration should also be extended to both the medium and large scale firms by providing an enabling business environment focused on reducing business costs which still remain prohibitively high.

The study further highlights the significance of firm location on firm performance. It has been established that regions with relatively well developed infrastructure and high population concentration are associated with high performing firms. The finding speaks to the need for infrastructure development in rural regions of Zambia which will not only reduce transport costs but also provide them with access to other regions with high demand for food products. This would result in increased scale efficiency and the optimization of scale economies by rural based firms.

4.2.Policy Implications

Policies should be aimed at enhancing productivity and profitability in the sector by promoting innovation and the adoption of new technologies so as to reduce the wastage of resources as revealed by the low technical efficiency scores. Therefore, the argument about building domestic human capital is valid. Investments in quality education should be prioritized in this regard so as to promote innovation and productivity. It has been argued that a certain minimum level of education is required for an entrepreneur to be able to upgrade his/her product lines to higher niches (Yoshino: 2011). This is particularly important to the food and beverage sector where the products are required to be of a healthy standard and of acceptable quality if the firm is to survive and grow.

The business environment should be improved by reducing unnecessary regulations that tend to increase the cost of starting and running a business. This would promote start-ups in the industry and offer competition to the established firms while creating a conducive environment for them to thrive. Infrastructure developments especially in the roads sector should be encouraged so that rural parts of the economy can be connected to the urban areas and open up urban markets for rural exploitation.

The study further provides technical insight which offers differentiated policy choices including but not limited to:

a. Concentrating on the relatively high technical efficient beverage and meat processing sectors by developing backward linkages that would improve the livelihood of fruit and cattle farmers while offering a lot more job opportunities in the value chain or
b. Promoting the small scale firms across the agro-processing industry which would open up business opportunities to more young entrepreneurs and reduce youth unemployment.

4.3.Limitations

Unfortunately, these preliminary conclusions are constrained by the following:

1. Data limitations: A single year cross-sectional dataset is limiting in many respects and does not allow for dynamic analysis of firm performance over time. Therefore, a panel dataset with more observations would help in understanding salient issues existing in the industry, including amongst others the industry's employment potential.
2. Omitted variables: Since the census dataset was not in the first place collected for the purpose of conducting efficiency analysis, there are not enough good variables with which to model differences in efficiency. For example, it would have been interesting to investigate the effect of the owner's experience and the business age on efficiency.

Notwithstanding these limitations, the findings obtained in this study are the best results that can be expected given the circumstances.

4.4.Recommendations for Further Research

This dissertation has analyzed the performance of the entire agro-processing industry assuming a homogenous technology frontier across all sectors. However, this is usually not the case especially in the food and beverage sector where firms exhibit complex technologies in their respective sectors. Therefore, it would be interesting to see what results from specific sectors of the agro-processing industry would reveal about the firm performance of the sector. Dynamic modelling with a panel dataset would also be revealing if data were available. It is worth noting that the Central Statistical Office of Zambia does not conduct an annual industrial census which makes it difficult to conduct such studies on Zambia.

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APPENDIXES

Appendix 1: The Share of Employment by Industry

Industry	Share of Employment (% of Total Employed Persons)		
	2008	**2012**	**2014**
Agriculture	71.3	52.2	48.9
Manufacturing	3.5	3.9	3.8
Wholesale&Retail trade	9.2	11.7	11.8
Activities of Household as employer	8.4	13.1	17.4

Source: CSO; Labour force survey reports (2008,2012&2014)

Appendix 2: Annual Population Growth Rates and Exchange Rates

Selected Years	2000	2002	2004	2006	2008	2010	2012	2014
Population growth (annual %)	2.6	2.5	2.6	2.8	2.9	2.9	3.0	3.1
Urban population growth (annual %)	1.3	3.7	3.7	3.9	4.0	4.1	4.1	4.2
Rural population growth (annual %)	3.3	1.9	1.9	2.1	2.2	2.3	2.3	2.3

Average Annual Exchange Rate

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Exchange Rate(ZMW/US$)	3.6	4.0	3.7	5.0	4.8	4.9	5.1	5.4	6.2	8.6

Source: World Bank database, retrieved from http://data.worldbank.org/ accessed December, 2015 and October, 2016.

Appendix 3: Zambia's Trading Partners (Food&Beverage in 2014)

	Food and live animals		Beverages	
Trading Partner	**% Total Exports**	**% Total Imports**	**% Total Exports**	**% Total Imports**
Democratic Republic of Congo	28.46		34.67	
South Africa	21.18	52.42		73.55
Zimbabwe	17.39	8.15	47.14	
Botswana	4.11			
Kenya	4.52	4.1		
Malawi	4.7			
Mauritius	7.33			
China		4.2		
Namibia		16.02		18.48

Source: UN Comtrade, retrieved from http://comtrade.un.org/ accessed December 2015

Appendix 4: Trade Balance of Zambia's Agro-Processing Industry (US$ Million)

HS Chapter	Product Description	Exports/Imports	2000	2005	2010	2013	2014	CAGR (2000-2014)
11	Products of the milling industry; malt; starches	Exports	7,065,020	9,088,142	33,173,528	68,217,414	47,586,385	**13.56%**
		Imports	2,889,282	6,229,113	7,444,284	12,630,317	8,235,680	**7.23%**
		Trade Balance	4,175,738	2,859,029	25,729,244	55,587,097	39,350,705	**16.13%**
16	Preparations of meat, fish & other aquatic invertebrates	Exports	16,177	939	407,193	1,415,889	302,601	**21.56%**
		Imports	1,231,975	795,527	1,954,693	2,932,860	2,847,561	**5.74%**
		Trade Balance	(1,215,798)	(794,588)	(1,547,500)	(1,516,971)	(2,544,960)	**5.05%**
17	Sugars and sugar confectionery	Exports	24,302,727	75,650,250	149,704,091	188,910,230	221,561,348	**15.87%**
		Imports	2,159,567	6,140,633	6,149,566	12,022,825	9,217,714	**10.16%**
		Trade Balance	22,143,160	69,509,617	143,554,525	176,887,405	212,343,634	**16.27%**
18	Cocoa and cocoa preparations	Exports	1,613	183,204	1,371,001	19,173,376	1,084,522	**54.35%**
		Imports	801,727	1,574,320	4,860,120	6,825,340	7,627,999	**16.21%**
		Trade Balance	(800,114)	(1,391,116)	(3,489,119)	12,348,036	(6,543,477)	**15.04%**
19	Preparations of cereals, flour, starch or milk; pastry cooks' products	Exports	342,438	210,658	10,635,019	16,177,655	14,247,585	**28.22%**
		Imports	3,878,336	6,732,800	16,912,601	28,849,096	31,639,140	**15.02%**
		Trade Balance	(3,535,898)	(6,522,142)	(6,277,582)	(12,671,441)	(17,391,555)	**11.20%**
20	Preparations of vegetables, fruit, nuts or other parts of plants	Exports	35,834	224,340	1,792,754	5,343,247	9,813,598	**45.38%**
		Imports	2,695,312	6,667,340	18,125,219	26,413,060	28,827,214	**17.12%**
		Trade Balance	(2,659,478)	(6,443,000)	(16,332,465)	(21,069,813)	(19,013,616)	**14.01%**
21	Miscellaneous edible preparations	Exports	96,627	14,495,717	1,881,787	12,705,617	10,096,934	**36.33%**
		Imports	6,730,371	6,971,365	19,699,011	31,126,149	34,463,803	**11.50%**
		Trade Balance	(6,633,744)	7,524,352	(17,817,224)	(18,420,532)	(24,366,869)	**9.06%**
22	Beverages, spirits and vinegar	Exports	599,469	468,242	11,864,411	215,908,319	14,100,406	**23.43%**
		Imports	2,448,088	3,203,013	16,148,517	35,346,505	38,082,122	**20.08%**
		Trade Balance	(1,848,619)	(2,734,771)	(4,284,106)	180,561,814	(23,981,716)	**18.63%**

Source: UN Comtrade, retrieved from http://comtrade.un.org/ accessed December 2015